## Unit 5: Communication systems

**Communication Systems:** Analog and Digital Communication: Fundamental Concepts with Block Diagram, Introduction to Cellular Communication, Computer Communication Networks and IOT.

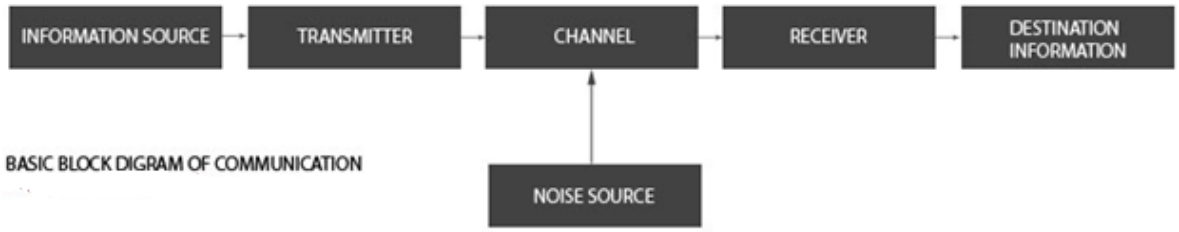
**6Hrs**

## Introduction to Analog Communications

Communication is the basic process of exchanging information. The term **communication** refers to transmission, reception and processing of information by electrical means.

The subject has its origin in the beginning of **wire telegraphy** in the middle of 19$^{th}$ century and **radio communication** at the beginning of 20$^{th}$ century. **Radio communication** is the process of sending information from one place and receiving at another place without using any connecting wires.it is also called **wireless communication**.

### Basic block diagram communication system




BASIC BLOCK DIGRAM OF COMMUNICATION

**Information**

The communication systems communicate messages. The message comes from the information sources.

Example: human voice, picture, code, data, music etc...

**Transmitter**

The transmitter is a collection of electronic circuits designed to convert the information into a signal suitable for transmission over a given communication medium.

**Communication channel**

The communication channel is the medium by which the electronic signal is transmitted from one place to Another.it can be a pair of conducting wire, coaxial cable, optical fiber or free space.

**Noise**

Noise is a random, undesirable electrical energy that enters the communication system via medium and interferes with the transmitted message.

**Receiver**

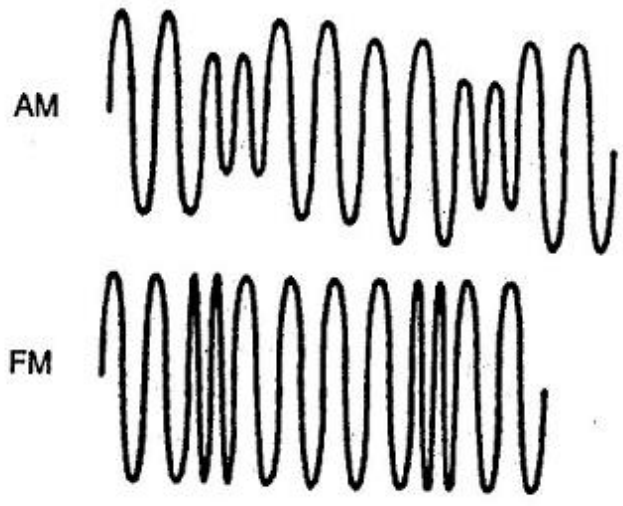
A receiver is a collection of electronic circuits designed to convert the signal back to the original information.

Communication systems can be fundamentally divided into two categories: ***Analog and Digital.***

**Analog** refers to a continuous, smooth change of signal. **Digital** system consists of discrete, distinguishable steps. Digital is further defined in terms of 2 possible steps known as 1 and 0, on and off, or true and false.

- In a historical context, Communications began as a strictly analog process. Original radio, telegraph, and even telephone systems were analog simply because a digital technique does not exist.
- Analog communication had an advantage since all information transmitted at that time was analog in nature.
- As solid state electronics evolved into integrated circuits and other devices, they showed an inherent advantage in speed, size and power consumption when compared to analog devices.
- Digital electronics led to the development of desktop and laptop computer, calculators and miniature radios.
- Digital environment is better than that of analog in many ways.

The properties of a periodic wave-shaped carrier are modified in an analog system to represent continuous voice or music signal that needs to be transmitted. The two simplest methods for accomplishing this are *amplitude modulation* (AM) and *frequency modulation* (FM). Amplitude modulation changes the amplitude of a carrier wave to represent communication signal. The carrier amplitude increases and decreases at a rate that corresponds to the frequency of the analog signal. In such a system, as with all analog communications, the wave that carries the information is known as the *carrier*. The data that is communicated is known as the *intelligence/modulating signal.* Frequency modulation changes the frequency of the carrier at a rate that corresponds to the changes in the amplitude of the intelligence signal. While AM can be considered as a compression of the carrier wave in the vertical direction, FM is the compression in the horizontal direction. Figure 14.1 illustrates the difference between AM and FM.




Waveform of AM and FM signals.

## Introduction to Digital Communications

### Digital system block design

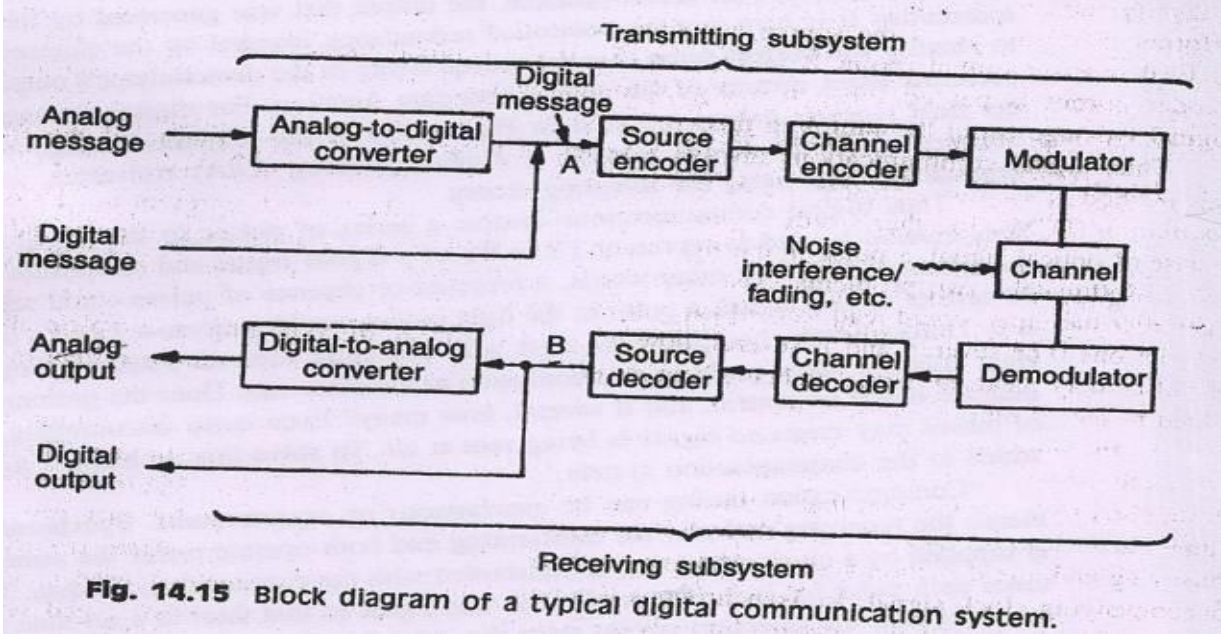



**Fig. 14.15** Block diagram of a typical digital communication system.

A typical communication system involves a **transmitting station (sender), a receiving station (user),** and a connecting medium called a **channel**.
A block diagram of the principal functions that may be present in a digital communication system is illustrated in the fig as the overall system is digital, the transmitting subsystem can accept such signals directly.

**Analog-to-Digital (A/D) converter**

- It can also work with analog signals if they are converted into digital form in the **analog-to-digital (A/D) converter**. A/D conversion involves periodically sampling the analog waveform and quantizing the samples.
- Quantization amounts to rounding to the nearest of a number amplitudes.
- However in the rounding process some information may be lost that limits the accuracy with which the analog signal can be reconstructed in the receiver.
- The actual output of the A/D converter at point A in the fig is a discrete voltage level. These levels can be represented by a sequence of binary representation, often binary digits 0 and 1.

**Source encoder**

- The purpose of source encoder is to effectively convert each discrete level into a suitable digital representation, often binary.
- Digital messages are said to process redundancy if their levels are not equally probable or are not statistically independent.
- The practical purpose of source encoder is to remove redundancy.

**Channel encoder**

- This block helps to reduce the effects of channel caused errors.
- This is achieved by adding controlled redundancy to the source encoder's digital representation in a known manner such that errors may be reduced.

**Channel**

The transmitted signal moves along with some errors/noise/interferences etc.. through a medium called channel

**Channel decoder**

The purpose is to reconstruct the signal to the best extent possible, the output that was generated by the source encoder and channel encoder.

**Source decoder**

It performs exact inverse of the source encoding function. For digital messages its output becomes the final receiver output.

**Digital-to-Analog converter**

If the original message was analog, the source decoder output is passed through a Digital-to-Analog converter which reconstructs the original message using sampling theory.

## Cellular communication

Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor.

The most common wireless technologies use radio. With radio waves, distances can be short, such as a few meters for television or as far as thousands or even millions of kilo meters for deep-space radio communications.

It consists of various types of fixed, mobile, and portable applications, including two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other examples of applications of radio wireless technology include GPS units, garage door openers, wireless computer mice (plural of mouse), keyboards and headsets, headphones, radio receivers, satellite television, broadcast television and cordless telephones.

Cell is the basic geographic service area of wireless communication system. A cellular communication system uses a large number of low- power wireless transmitters to create cells.

A Mobile Station (MS) or subscriber unit communicates to a Base Station (BS) which in turn communicates to the desired user at the other end.

The MS consists of transceiver, control circuitry, duplexer and an antenna while the BS consists of transceiver and channel multiplexer along with antennas mounted on the tower.

The BS is also linked to a power source for the transmission of the radio signals for communication and is connected to a backbone network.

The basic mobile communication consists of low power transmitters/receivers at the BS, the MS and also the Mobile Switching Centre (MSC).

The MSC is sometimes also called Mobile Telephone Switching Office (MTSO). The radio signals emitted by the BS, decay as they travel away from it.

A minimum amount of signal strength is needed in order to be detected by the mobile stations or mobile sets which are the hand-held personal units (portables) or those installed in the vehicles (mobiles).

The region over which the signal strength lies above such a threshold value is known as the coverage area of a BS.

The backbone network is a wired network that links all the base stations and also the landline and other telephone networks through wires.

A cellular system can further be subdivided into two categories: a single MS for a BS, and many MS for a single BS. Cordless telephone systems are full duplex communication systems that use radio to connect to a portable handset to a single dedicated BS, which is then connected to a dedicated telephone line with a specific telephone number on the Public Switched Telephone Network (PSTN). A mobile system, in general, on the other hand, is the example of the second category of a full duplex mobile system where many users connect among themselves via a single BS.

## Evolution of Cellular Communications

Cellular technology is the underlying technology for mobile telephones, personal communications systems, wireless Internet and wireless Web applications, and much more. The cellular technology has evolved through the generations as discussed below.

### First Generation (1G)

The original cellular networks, now named as 1G, provided analog traffic channels and were designed to be an extension of the public switched telephone networks.

Users with brick - sized cell phones placed and received calls in the same fashion as landline subscribers.

The most widely deployed 1G system was the Advanced Mobile Phone Service (AMPS), developed by AT&T.

The channels (frequency bands) carry the conversations in analog using frequency modulation.
The number of channels is inadequate for many larger areas. So, for AMPS, frequency reuse is exploited by allowing the same frequency band to be used in non-adjacent cells.

**Second Generation**

Second-generation (2G) systems were developed to provide higher - quality signals, higher data rates for support of digital services and greater capacity. Key differences between 1G and 2G networks are as below:

1. Digital traffic channels: The most notable difference between the two generations is that 1G systems are almost purely analog, whereas 2G systems are digital. In particular, 1G system is designed to support voice channels; digital traffic is supported only by the use of a modem that converts the digital data into analog form. 2G systems provide digital traffic channels. 2G systems readily support digital data; voice traffic is first encoded in digital form before transmitting.
2. Encryption: Because all of the user traffic, as well as control traffic, is digitized in 2G systems, it is a relatively simple matter to encrypt all of the traffic to prevent eavesdropping. All 2G systems provide this capability, whereas 1G system sends user traffic in the clear, providing no security.
3. Error detection and correction: The use of error detection and correction techniques in digital traffic stream of 2G systems is very easy. So, the result will be usually with fewer errors.
4. Channel access: In 1G system, each cell supports a number of channels. At any given time a channel is allocated to only one user. 2G systems also provide multiple channels per cell, but each channel is dynamically shared by a number of users using time division multiple access (TDMA).

**Third Generation**

The objective of the third generation (3G) of wireless communication is to provide fairly high – speed wireless communications to support multimedia, data, and video in addition to voice. The dominant technology for 3G systems is CDMA. The design features of CDMA are:-

1. Bandwidth: An important design goal for all 3G systems is to limit channel usage to 5 MHz. But, a bandwidth of 5 MHz or more improves the receiver's ability to resolve multipath when compared to narrower bandwidths. On the other hand, available spectrum is limited by challenging needs, and 5 MHz is a reasonable upper limit that can be allocated for 3G.
2. Data rate: The data rates of 144 and 384 kbps are the usually supported by 3G network. Some 3G systems also provide support up to 2 Mbps for office use.
3. Multirate: The term multirate refers to the provision of multiple fixed-data-rate channels to a given user, in which different data rates are provided on different channels. The advantage of multirate is that the system can flexibly support multiple simultaneous applications from a given user.

**Fourth Generation**

4G systems provide ultra-broadband Internet access for a variety of mobile devices including laptops, smartphones, and tablets.
4G networks support Mobile Web access and high-bandwidth applications such as high-definition mobile TV, mobile video conferencing, and gaming services.
4G systems have the following characteristics:

1. Support peak data rates of up to approximately 100 Mbps for high-mobility mobile access and up to approximately 1 Gbps for low-mobility access such as local wireless access.
2. Dynamically share and use the network resources to support more simultaneous users per cell.
3. Support smooth handovers across heterogeneous networks.
4. Support high quality of service for next-generation multimedia applications.

In contrast to earlier generations, 4G systems do not support traditional circuit - switched telephony service, providing only IP telephony services.

4G systems use orthogonal frequency - division multiple access (OFDMA) technique, multicarrier transmission, frequency – domain equalization schemes and multiple – input - multiple - output (MIMO) antennas.

**Fifth Generation**

5G systems are still some years away (perhaps 2020) but likely 5G technologies are an area of active research. By 2020, the huge amounts of data traffic generated by tablets and smartphones will be greater than before because of larger amount of traffic from the "Internet of things".

## Internet of Things (IoT):

The Internet Of Things will make many of the familiar devices and objects in our lives - from door locks to toll booths to refrigerators - suddenly Internet-connected, smartphone-accessible, and responsive. Internet of things can be split into two terms"Internet" and "Things", i.e. connecting things through internet. Internet of things or in short IoT is the ability to network electronics in a standard way is set to revolutionize intelligent device control.

- Internet is as everyone knows symbolizes connectivity and things symbolizes is whatever is around you. So it tells you that whatever around connected to internet is known as IoT. It can be a refrigerator, TV, micro oven, Camera etc connected to internet is simply defined it as internet of things.
- It collects data from device with the help of sensor and stores those data in cloud, analyze those data and advice the user in a more understanding manner.
- It acts as self-advising about its working which make device look more intelligent. It also known as internet connected intelligence.

It has two main layers Hardware and Software.

### Hardware

The special hardware which IoT has in its device is sensors. What these sensors do is, they capture the data flowing in the device and pass it on to cloud where these will be stored, analyzed and reach back to you through app.

### Software

The second layer of IoT products is the software that analyses data flows from sensors. For instance, a building sensor will generate big data that can create a lot of value. Such data could be extracted to optimize heating and lighting in a building controlled via an IoT-based sensor network.

There are the six main attributes that make "things" a part of the Internet of Things, or IoT:

•**Sensors:**IoT devices and systems include sensors that track and measure activity in the world. One example is Smartthings' open-and-close sensors that detect whether or not a drawer, window, or door in your home is open or closed.

•**Connectivity:** Internet connectivity is either contained in the item itself, or a connected hub, smartphone, or base station. If it's the latter, then the base station will likely be collecting data from an array of sensor-laden objects, and relaying data to the cloud and back.

•**Processors:** Just like any computing device, IoT devices will contain some computing power or it will be able to parse incoming data and transmit it.

•**Energy-efficiency:** Many devices in the IoT may be difficult, costly, or dangerous to access for charging or battery replacement. Therefore, they may need to be able to operate for a year or more unattended using a conservative amount of energy or be able to wake up only periodically to relay data.

•**Cost-effectiveness:** Objects that contain sensors may need to be distributed broadly to be useful, as in the case of sensors in food products in supermarkets that would indicate if an item has spoiled. These would need to be relatively inexpensive to purchase and deploy.

•**Quality and reliability:** Some IoT devices will need to operate in harsh environments outdoors and for extended periods of time.

•**Security:**IoT devices may need to relay sensitive or regulated information such as health-related data, so data security will be critical.

These characteristics all apply to today's smartphones, of course, but many IoT devices will also need to be equipped with several special features to be truly useful. These will differentiate IoT devices, particularly remote ones, from today's smartphones.

The Internet of Things (IoT) is a scenario in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS) and the Internet.

**How IoT is used in daily life? Examples**

1. As you approach the front door of your house, a remote control built into your key unlocks the door. The door's wireless radio messages the network, which prompts the hall light to turn on. The house thermostat, which was lowered after you left for work, returns to a comfort zone. Everything is acting in concert, which brings us to the elegant definition of IoT. A true Internet of Things is coordination between multiple devices."
2. You are on your way to a meeting, your car could have access to your calendar and already know the best route to take, if the traffic is heavy your car might send a text to the other party notifying them that you will be late.
3. Your alarm clock wakes up you at 6 am and then notifies your coffee maker to start brewing coffee for you.

So, IoT can be said as a very interesting present and future research topic.

**Computer Communication Networks:**

# Computer network

A **computer network**, or **data network**, is a digital telecommunications network which allows nodes to share resources. In computer networks, computing devices exchange data with each other using connections (data links) between nodes. These data links are established over cable media such as wires or optic cables, or wireless media such as WiFi.

Network computer devices that originate, route and terminate the data are called network nodes. Nodes are identified by network addresses and can include hosts such as personal computers, phones, servers as well as networking hardware. Two such devices can be said to be networked together when one device is able to exchange information with the other device, whether or not they have a direct connection to each other. In most cases, application-specific communications protocols are layered (i.e. carried as payload) over other more general communications protocols. This formidable collection of information technology requires skilled network management to keep it all running reliably.

Computer networks support an enormous number of applications and services such as access to the World Wide Web, digital video, digital audio, shared use of application and storage servers, printers, and fax machines, and use of emailand instant messaging applications as well as many others. Computer networks differ in the transmission medium used to carry their signals, communications protocols to organize network traffic, the network's size, topology, traffic controlmechanism and organizational intent. The best-known computer network is the Internet.

A computer network facilitates interpersonal communications allowing users to communicate efficiently and easily via various means: email, instant messaging, online chat, telephone, video telephone calls, and video conferencing. A network allows sharing of network and computing resources. Users may access and use resources provided by devices on the network, such as printing a document on a shared network printer or use of a shared storage device. A network allows sharing of files, data, and other types of information giving authorized users the ability to access information stored on other computers on the network. Distributed computing uses computing resources across a network to accomplish tasks.

## Network packet

Computer communication links that do not support packets, such as traditional point-to-point telecommunication links, simply transmit data as a bit stream. However, most information in computer networks is carried in packets. A network packet is a formatted unit of data (a list of bits or bytes, usually a few tens of bytes to a few kilobytes long) carried by a packet-switched network. Packets are sent through the network to their destination. Once the packets arrive they are reassembled into their original message.

Packets consist of two kinds of data: control information, and user data (payload). The control information provides data the network needs to deliver the user data, for example: source and destination network addresses, error detection codes, and sequencing information. Typically, control information is found in packet headers and trailers, with payload data in between.

# Network links

The transmission media used to link devices to form a computer network include electrical cable, optical fiber, and radio waves.

**Wired technologies**

Coaxial cable is widely used for cable television systems, office buildings, and other work-sites for local area networks. Twisted pair cabling is used for wired Ethernet and other standards. An optical fiber is a glass fiber. It carries pulses of light that represent data. Optical fibers can simultaneously carry multiple wavelengths of light, which greatly increases the rate that data can be sent, and helps enable data rates of up to trillions of bits per second.

**Wireless technologies**

Terrestrial microwave, Communications satellites, Cellular and PCS systems, Radio and spread spectrum technologies, Free-space optical communication.

**Network nodes**

Apart from any physical transmission media there may be, networks comprise additional basic system building blocks, such as network interface controllers (NICs), repeaters, hubs, bridges, switches, routers, modems, and firewalls. Any particular piece of equipment will frequently contain multiple building blocks and perform multiple functions.

**Network interfaces**

A network interface controller (NIC) is computer hardware that provides a computer with the ability to access the transmission media, and has the ability to process low-level network information.

**Repeaters and hubs**

A repeater is an electronic device that receives a network signal, cleans it of unnecessary noise and regenerates it. The signal is retransmitted at a higher power level, or to the other side of an obstruction, so that the signal can cover longer distances without degradation.

**Bridges**

A network bridge connects and filters traffic between two network segments to form a single network. Network segmentation breaks down a large, congested network into an aggregation of smaller, more efficient networks.

**Switches**

A network switch is a device that forwards and filters frames between ports based on the destination (Medium Access Control) MAC address in each frame.[17] A switch is distinct from a hub in that it only forwards the frames to the physical ports involved in the communication rather than all ports connected.

**Routers**

A router is an internetworking device that forwards packets between networks by processing the routing information included in the packet or datagram. The routing information is often processed in conjunction with the routing table (or forwarding table). A router uses its routing table to determine where to forward packets.

**Modems**

Modems (MOdulator-DEModulator) are used to connect network nodes via wire not originally designed for digital network traffic, or for wireless. Modems are commonly used for telephone lines, using a Digital Subscriber Line technology.

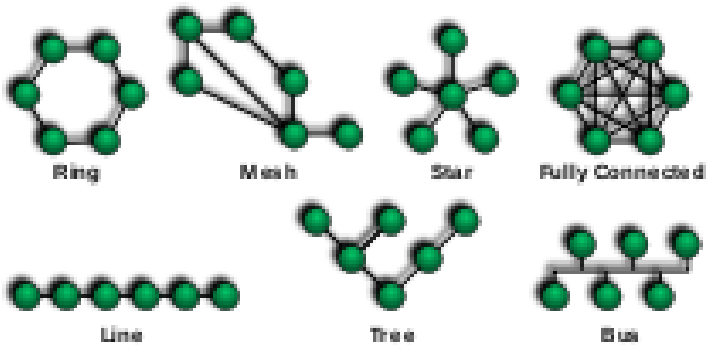
**Firewalls**

A firewall is a network device for controlling network security and access rules. Firewalls are typically configured to reject access requests from unrecognized sources while allowing actions from recognized ones. The vital role firewalls play in network security grows in parallel with the constant increase in cyber attacks.

**Network structure**

Network topology is the layout or organizational hierarchy of interconnected nodes of a computer network.

**Common layouts**




Common network topologies

Common layouts are:

A bus network: all nodes are connected to a common medium along this medium. This was the layout used in the original Ethernet, called 10BASE5 and 10BASE2. This is still a common topology on the data link layer, although modern physical layer variants use point-to-point links instead.

A star network: all nodes are connected to a special central node. This is the typical layout found in a Wireless LAN, where each wireless client connects to the central Wireless access point.

A ring network: each node is connected to its left and right neighbour node, such that all nodes are connected and that each node can reach each other node by traversing nodes left- or rightwards. The Fiber Distributed Data Interface (FDDI) made use of such a topology.

A mesh network: each node is connected to an arbitrary number of neighbours in such a way that there is at least one traversal from any node to any other.

A fully connected network: each node is connected to every other node in the network.

A tree network: nodes are arranged hierarchically.

A network can be characterized by its physical capacity or its organizational purpose. Use of the network, including user authorization and access rights, differ accordingly.

Personal area network

A personal area network (PAN) is a computer network used for communication among computer and different information technological devices close to one person. Some examples of devices that are used in a PAN are personal computers, printers, fax machines, telephones, PDAs, scanners, and even video game consoles.

Local area network

A local area network (LAN) is a network that connects computers and devices in a limited geographical area such as a home, school, office building, or closely positioned group of buildings. Each computer or device on the network is a node.

The defining characteristics of a LAN, in contrast to a wide area network (WAN), include higher data transfer rates, limited geographic range, and lack of reliance on leased lines to provide connectivity.

Home area network

A home area network (HAN) is a residential LAN used for communication between digital devices typically deployed in the home, usually a small number of personal computers and accessories, such as printers and mobile computing devices. An important function is the sharing of Internet access, often a broadband service through a cable TV or digital subscriber line (DSL) provider.

Metropolitan area network

A Metropolitan area network (MAN) is a large computer network that usually spans a city or a large campus.

Wide area network

A wide area network (WAN) is a computer network that covers a large geographic area such as a city, country, or spans even intercontinental distances. A WAN uses a communications channel that combines many types of media such as telephone lines, cables, and air waves.